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Guidelines

Recommendations from the Association for European Paediatric Cardiology for training in paediatric cardiac intensive care
AEPC's recommendations for European paediatric cardiology trainees
The Working Group on Paediatric Cardiac Intensive Care

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Abstract The following document provides a summary of the guidelines and recommendations for paediatric cardiac intensive care training as a requirement for recognition as a European paediatric cardiologist. It is therefore primarily targeting paediatric cardiology trainees in Europe, including those doctors who might wish to become experts in cardiac intensive care. These recommendations represent a frame for consistency, will evolve, and may be adapted to specific institutional requirements. They will be complemented by a learning module to be provided by our Association in the near future.

Keywords: Paediatric cardiology; paediatric intensive care; training; guidelines

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THE OVERALL IMPROVING RESULTS IN THE management of congenital and acquired cardiac diseases are the result of an intense multidisciplinary effort, and of the search for consistency, quality, improvement, and safety that should be promoted from the training period.

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This important interaction between paediatric and adult cardiologists, cardiac surgeons, intensivists, anaesthetists, nurses, research staff, perfusion technicians, psychologists, nutritionists, physiotherapists, and other specialised caregivers, optimises conditions to provide an outstanding quality of care to our patients and their families. The advantages of such interdisciplinary collaboration widely justify our bid to include a rotation through the arena of cardiac intensive care for trainees in paediatric cardiology, who may even fully develop comprehensive dual skills in both cardiology and intensive care. The latter is a crucial matter, because clinical paediatric cardiologists may be primarily in charge of the management of

Table 1. Level 1 (basic) of training in paediatric cardiac intensive care for paediatric cardiology trainees.

Theoretical knowledge
Neonatal circulation, transition to extra-uterine circulation, and its impact on the clinical management of critically ill neonates with cardiac disease
Critical diagnosis and basic medical, pre- and post-operative and post-interventional management of the most common congenital and acquired cardiac diseases from neonates to adults
Invasive and non-invasive cardiac monitoring (NIBP; EKG; oxymetry; capnography; arterial lines; venous central lines; intra-cardiac lines including right atrial, left atrial, SVO_2, pulmonary artery lines; Swan–Ganz catheter; emerging technologies)
Evaluation and treatment of common neonatal cardio-circulatory disturbances, in the absence of cardiac defects (that is, persistent ductus arteriosus of the premature baby, increased pulmonary vascular resistances secondary to persistent foetal circulation pattern)
Evaluation and treatment of common cardio-circulatory disturbances in infants and adolescents, in the absence of cardiac defects (that is, cardiac dysfunction in septic shock, trauma, metabolic diseases)
Knowledge of the currently used scores of severity in the ICU arena (that is, RACHS, PRISM, Aristotle)
Basic knowledge on pharmacokinetics and use of cardiovascular drugs, including the management of their side effects and interactions
Knowledge in the use of Prostaglandins E_1, anti-coagulants, diuretics, and the management of their side effects and interactions
Cardio-pulmonary interactions
Basic notions of cardiac anaesthesia
Basic notions of cardio-pulmonary bypass (CPBP), normo versus hypothermia, deep hypothermia circulatory arrest (DHCA)
Basic notions on assessment and management of sedation, anxiolysis, and pain
Basic notions on mechanical ventilation
Basic notions on nursing care and algorithms
Basic notions on nutrition of the critically ill cardiac patient
Basic notions of cardiac and non-cardiac complications of cardiac surgery (renal, neurological, respiratory, haematological, gastrointestinal, infectious)
Development of a philosophy of care and promotion of team work in the context of multidisciplinarity
Acquisition of PALS and ACLS accreditation, including cognitive and skills evaluation
Practical skills
Use of external pacemakers (external pads, epicardial leads, trans-thoracic pacing) and endovascular pacemakers

NIBP = non-invasive blood pressure; EKG = electrocardiogram; ICU = intensive care unit; PALS = paediatric advanced life support; ACLS = advanced cardiac life support

critically ill cardiac patients, from neonates to adults, or else will often be asked to advice on such patients.

Europe is a complex forum to develop homogeneous guidelines for training in paediatric cardiac intensive care, since hosting varied patterns of training and practitioner backgrounds. Thus, the format for training of future paediatric cardiologists ought to ally tradition with innovation. Nevertheless, consistency will be an important key to success.

The following document provides a summary of the guidelines and recommendations for paediatric cardiac intensive care training as a requirement for recognition as a European paediatric cardiologist. It is therefore primarily targeting paediatric cardiology trainees in Europe, including those doctors who might wish to become experts in cardiac intensive care. These recommendations represent a frame for consistency, will evolve, and may be adapted to specific institutional requirements. They will be complemented by a learning module to be provided by our Association in the near future.

Training in the field of paediatric cardiac intensive care concerns many entities, and therefore a strong collaboration within an interdisciplinary faculty is required. The future will hopefully bring further developments in training requirements in compliance with other Societies involved with paediatric critical patients, like the European Society of Paediatric and Neonatal Intensive Care, the European Association for Cardiothoracic Surgery, the European Association of Cardiothoracic Anesthesiologists, and other analogue entities, as well as with the future European Board of Intensive Care and the European Union of Medical Specialists. Future initiatives will also promote the inclusion, whenever possible, of simulation techniques for training in paediatric cardiac intensive care.

Institutional requirements for delivery of training

Specialised centres wishing to provide training in paediatric cardiac intensive care should ideally perform at least 100 open-heart surgeries a year for levels 1 and 2 and 150 open-heart procedures for level 3,[1–4] in order to provide a significant volume and variety of patients in a solid academic and clinical structure. Such centres should be able to provide clinical and academic discussions, teaching sessions, journal clubs, and revision of related subjects that must be held on a regular basis.[5] An oversight tutor or committee should be set to supervise, review training goals, and review a logbook with the trainee on a regular basis. Accredited institutions should also participate in the EACTS-STS database and use the Aristotle score.

It is strongly recommended that a detailed curriculum be followed, as defined by the tutor

Table 2. Level 2 (intermediate) of training in paediatric cardiac intensive care for paediatric cardiology trainees.

Theoretical knowledge
Proficiency in the aspects required for level 1 training
Broader knowledge of the equipment used in the intensive care (that is, monitors, syringe-pumps, ventilators); familiarity with troubleshooting algorithms for equipment dysfunction
Higher knowledge in the identification of early clinical and biological markers of complications after cardiac surgery or diagnostic and interventional catheterisation
More advanced knowledge of pathophysiologic mechanisms involved in the management of non-surgical patients admitted for diseases such as cardiac failure, myocarditis, Kawasaki disease, endocarditis, rheumatic fever
More advanced knowledge on algorithms to troubleshoot and manage complex arrhythmias in the post-operative period (interpretation of atrial EKG, management of junctional ectopic tachycardia, management of cardioversion and defibrillation, R-synchronised inverted pacing modalities)
Knowledge in the identification and management of the different pathophysiological types of circulatory shock in cardiac patients (cardiogenic, distributive, obstructive, dissociative)
Advanced knowledge on the early diagnosis and management of post-operative low cardiac output syndrome
Advanced knowledge on the management of tetralogy of Fallot's hypoxic spells
Proficiency in the use of cardiovascular drugs (as described in level 1)
Proficiency in the management of acute and chronic decompensated pulmonary hypertension (ventilatory strategies, use of intravenous and inhaled pulmonary vasodilators, identification and management of triggering factors)
Knowledge in the acute management of cardiac transplant, including transplant drugs and their side effects and interactions, and in the management of acute graft rejection
Knowledge on management of multi-organ dysfunction, peritoneal dialysis and basic management of mechanical assist devices, with emphasis on extracorporeal membrane oxygenation (ECMO)
Broad knowledge on principles of patient and staff safety, quality improvement, audit and guidelines in the field
Attendance to paediatric cardiac surgical interventions in the operating room in order to become more familiar with the cardio-pulmonary bypass sequence, the details of myocardial protection, use of CPBP pump, notions of aortic cross-clamp and CPB duration, and peri-operative anaesthetic details*
Development of the awareness of the importance and the implications of complications and eventual sequelae on the early and late follow-up of patients and their families
To learn the basic principles and ethical considerations of palliative and end-of-life care
Active involvement in teaching peers, nurses, and other caregivers, as well as the patients and their families
Practical skills
Proficiency with basic oral and nasal tracheal intubation
Management of CPAP, BiPAP, high flow and mechanical ventilators
Insertion of percutaneous pericardial drains and pleural drains in toddlers and infants
Insertion of percutaneous peritoneal dialysis catheters (optional)**
Insertion of radial, ulnar, brachial and femoral arterial catheters*** in toddlers and infants
Insertion of external and internal jugular, subclavian, and femoral central venous catheters*** in toddlers and infants

EKG = electrocardiogram

*The tutor(s) in charge of the trainees may wish to liaise with their sections of Anaesthesia and Cardiac Surgery to organise this rotation

**In some institutions, this procedure might be exclusive to surgical caregivers; it is therefore recommended, although not mandatory, to get acquainted with the technique

***The tutor(s) in charge of the trainee may wish to liaise with their Anaesthesia section to organise specific rotations in the operating rooms for this purpose

Note: some of these requirements may need to be fulfilled with rotations in specific high-volume centres

and compliant with a learning module provided by the Association for European Paediatric Cardiology.

For specific modalities, such as circulatory mechanical assistance, complex neonatal surgery, or cardiac transplant, the trainee may rotate if desired in a recognised specialised institution.

Requirements for trainees

It is impossible and futile to pretend that all paediatric cardiologists become experts in the field of paediatric cardiac intensive care. Nevertheless, *it is crucial that all paediatric cardiologists become familiar with the common issues related to critical care*.[6] Prior to training in paediatric cardiac intensive care, paediatric cardiology trainees should have a general background on normal and abnormal physiology of the cardiovascular system, aetiology, diagnosis and differential diagnosis of congenital and acquired diseases, electrocardiography, echocardiography, cardiovascular radiology, rhythmology, and cardiovascular pharmacology. Candidates should therefore have completed at least 1 year of paediatric cardiology and 3–6 months of neonatal intensive care, as required in the guidelines and recommendations for general paediatric cardiology training.

Trainees should keep a comprehensive logbook specifying demographic data of patients, technical procedures performed while in training, attendance to teaching sessions and speciality meetings,

Table 3. Level 3 (advanced) of training in paediatric cardiac intensive care for paediatric cardiology trainees.

Theoretical knowledge
Proficiency in the aspects required for Level 2 training
Wide knowledge of updated literature, innovative ideas, and current studies related to all aspects of intensive care, with emphasis, but not exclusively, on cardiac aspects
Development of skills in the prioritisation, organisation, and optimisation of patient transfer from the operating room, the haemodynamics laboratory or the wards onto the intensive care unit
Advanced knowledge of the equipment used in the cardiac intensive care arena including algorithms to troubleshoot dysfunctional equipment
Advanced knowledge in the management of severe multi-organ failure
Advanced knowledge in re-synchronisation therapy in the intensive care environment
Advanced knowledge in the management of extra-cardiac complications
Renal: renal failure and replacement therapy
Respiratory: ARDS, pneumopathies, BPD, tracheal and bronchial malacia, respiratory physiotherapy
Gastrointestinal: NEC, enterocolitis, protein-losing enteropathy, surgical emergencies (perforation, volvulus, malrotation), liver insufficiency
Haematological: anti-coagulation, heparin-induced thrombocytopenia, plasma exchange
Neurological: stroke, intracranial bleeding, seizures
Infectious: sepsis, mediastinitis, prophylaxis of infection
Malnutrition: feeding difficulties, guidelines for enteral and parenteral feeding
Other: skin protection, functional therapy
Advanced skills in the diagnosis and management of less frequent post-operative complications such as residual cardiac lesions, diaphragmatic and vocal chordae palsy, chylothorax, chronic respiratory complications
Practical skills
Proficiency with the skills described for Level 2 training, extended to the neonatal period
Management and troubleshooting of ExtraCorporeal Life Support techniques, including extracorporeal membrane oxygenation (ECMO), uni and bi-ventricular assist devices (LVAD, RVAD, BiVAD) and intra-aortic balloon pump (IABP)
Proficiency in the management of Continuous Renal replacement Therapy (CRRT) including CVVH, CVVHD, and CVAHD
Proficiency in the management of difficult oral and nasal airway intubation*
Training in emergent chest-opening techniques**

ARDS = acute respiratory distress syndrome; BPD = broncho-pulmonary dysplasia; NEC = necrotizing enterocolitis; CVVH = continuous veno-venous hemofiltration; CVVHD = continuous veno-venous hemodiafiltration; CVAHD = continuous veno-arterial hemodiafiltration

*The tutor(s) in charge of the trainee may wish to liaise with their Anaesthesia section to organise specific rotations in the operating rooms for this purpose

**In some institutions, this procedure might be exclusive to surgical caregivers; it is therefore recommended, although not mandatory, to get acquainted with the technique

published papers and research projects they have been involved with. This requirement will have the purpose of documenting[7–13] a breadth of exposure to the training resources and must be monitored on a regular basis by the tutor or committee in charge.

There will be three levels of training available to trainees, the first one – basic – being the minimal required to become a European paediatric cardiologist, the second level – intermediate – being available to those wishing to become more independent in the management of paediatric cardiac critical care patients, and the third level – advanced – offered to candidates, who wish to further develop their expertise in order to become specialists in paediatric cardiac intensive care.

Levels of training

Level 1

The basic level 1 of training is required for *all* paediatric cardiology trainees, for a period of 6 months. It provides an understanding of the clinical and pathophysiological assessment of critical medical and surgical paediatric cardiac patients, the use of cardiovascular monitoring, and facilitates the acquisition of knowledge allowing the use of cardiovascular drugs and pacemakers, and the anticipation of potential complications (Table 1).

Level 2

Level 2 or intermediate level of training will enable paediatric cardiologists to become more independent and knowledgeable in the assessment and management of critical complex cardiac diseases from the neonatal period to adulthood. This includes management of medical conditions, post-operative care, and, whenever possible, cardiac transplant. It will also allow the development of skills with regard to the insertion of pericardial and thoracic drains and indwelling catheters, basic oral and nasal tracheal intubation, management of multi-organ dysfunction, peritoneal dialysis and basic management of mechanical assist devices, with emphasis on extracorporeal membrane oxygenation. A training period of 9 months would be required to achieve this level. Trainees will have to be certified by their trainers as competent, based on the clinical

performance and acquisition of skills, rather than on the number of patients (Table 2).

Level 3

Level 3 or advanced level of training will require a minimum of 12 months rotation, as a *complementary year after the full training in paediatric cardiology including level 2 competencies*, in a programme offering exposure to neonatal and grown-up congenital heart patients. Training in cardiac transplant, Extracorporeal Membrane Oxygenation, and other types of mechanical assistance is suggested. It will enable paediatric cardiologists to become paediatric cardiac intensivists, proficient, and autonomic in the comprehensive management of critically ill cardiac patients, from the neonatal period to adulthood. This includes the development of capacities to anticipate, prevent, and manage potential cardiac or non-cardiac complications. This level will provide expertise in the management of multi-organ failure, mechanical assistance – extracorporeal membrane oxygenation and ventricular assist devices – and, if possible, Continuous Renal Replacement Therapy. It will also promote the development of higher-level skills with invasive procedures such as insertion of indwelling venous and arterial lines, pericardial and thoracic drains, and eventually difficult airway intubation. At the end of the training period, trainees should be able to *independently* manage complex cardiac patients (Table 3).

Assessment of training

The trainee's proficiency will be assessed upon the logbook and the tutor's appraisal. The oversight tutor(s) or committee is required to meet with the trainees every 3 months to review the achievement of goals, and provide orientation in order to optimise training. Tutors are also required to supervise and validate the development of skills with regard to invasive procedures. At the end of the training period, the assigned tutor(s) will be required to certify the trainees' competencies in their respective level of training. It is also suggested that trainees evaluate their trainers following premises established by the Association for European Paediatric Cardiology Council.

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